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Associations between lifestyle factors and an unhealthy diet

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Background: Unhealthy dietary patterns have been associated with other unhealthy lifestyle factors such as smoking and physical inactivity. Whether these associations are similar in high- and low-educated individuals is currently unknown. **Methods**: We used information of the EPIC-NL cohort, a prospective cohort of 39 393 men and women, aged 20–70 years at recruitment. A lifestyle questionnaire and a validated food frequency questionnaire were administered at recruitment (1993–97). Low adherence to a Mediterranean-style diet was used to determine an unhealthy dietary pattern. Lifestyle-related factors included body mass index, waist circumference, smoking status, physical activity level, dietary supplement use and daily breakfast consumption. Multivariate logistic regression analyses were performed for the total population and by strata of educational level. **Results**: In total 30% of the study population had an unhealthy dietary pattern: 39% in the lowest educated group and 20% in the highest educated group. Physical inactivity, a large waist circumference, no dietary supplement use and skipping breakfast were associated with an unhealthy dietary pattern in both low and high educated participants. Among low educated participants, current smokers had a greater odds of an unhealthy diet compared with never smokers: OR 1.42 (95% CI: 1.25; 1.61). This association was not observed in the high educated group. **Conclusions**: Most associations between lifestyle-related factors and unhealthy diet were consistent across educational levels, except for smoking. Only among low educated participants, current smokers reported an unhealthier dietary pattern in comparison to never smokers. These results can be used in the development of targeted health promotion strategies.

Introduction

An unhealthy diet is associated with a higher risk of chronic diseases and mortality.[1] Up to 4% of the global disease burden has been related to an unhealthy diet,[2] making diet one of the important modifiable lifestyle factors. Other lifestyle-related factors that are associated with an increased chronic disease risk are smoking status, body mass index (BMI) and physical activity level. Addressing a combination of these modifiable lifestyle factors in health promotion strategies may result in a large health gain.[3]

Many studies have related an (un)healthy diet to socio-demographic or lifestyle factors. A low educational level, a low income or a low occupational position have been associated with an unhealthy diet,[4] while a higher educational level or occupational position have been associated with a healthy diet.[5,6] Furthermore, physical inactivity, smoking and a young age were all related to an unhealthy diet.[7,8] Unhealthy behaviors tend to co-exist, especially in persons with a low socio-economic status.[9,10] However, similar clusters of lifestyle behaviors have been reported in low, moderate and high educated persons, i.e. de Vries *et al.*[11] replicated a healthy, an unhealthy and a poor nutrition cluster in three different education groups, using latent class analysis.[11] Whether associations between individual unhealthy behaviors have a similar direction and size among low and high educated people has not been investigated to date. We were therefore interested in education-specific associations between unhealthy lifestyle behaviors. We aimed to investigate in the Netherlands whether associations between unhealthy lifestyle-related factors and unhealthy diets differ between people with a low and a high educational level. In addition to smoking status, body weight and physical activity level, we also studied supplement use and daily breakfast consumption. Supplement use has been associated with having a healthier diet,[12,13] while skipping breakfast has been associated with a lower chance of meeting recommended nutrient intakes, unhealthier dietary patterns and associated chronic diseases.[14] Our aim was to find out if these factors relate to diet to the same extent in low and high educated persons. These data may be helpful in designing tailored interventions. We used the modified Mediterranean Diet Score (mMDS) to define healthy or unhealthy dietary patterns, because this pattern was related to a decrease in chronic diseases[15] and to a longer health expectancy in our cohort, the European Prospective Investigation into Cancer and Nutrition–The Netherlands (EPIC-NL) cohort.[16]

Methods

Study population

We used baseline data on education, nutrition and other lifestyle-related characteristics of the EPIC-NL cohort in the Netherlands.[17] Between 1993 and 1997, 40 011 men and women aged 20–70 years were recruited. At recruitment, we administered a general questionnaire and a validated food frequency questionnaire (FFQ) and participants underwent a physical examination. All participants provided informed consent. The study complies with the Declaration of Helsinki and was approved by the Institutional

Review Board of the University Medical Center Utrecht and the Medical Ethical Committee of TNO Nutrition and Food Research. Exclusion criteria for the present analysis were: missing dietary information at baseline (n = 218) or implausible energy intake levels (being in the top or bottom 0.5% of the ratio of reported energy intake over estimated energy requirement, n = 400). In total 39 393 participants were included in the current analysis.

Definition of unhealthy dietary patterns

Dietary intake at recruitment was assessed with a validated FFQ[18] that contained questions on the habitual frequency of consumption of 79 foods during the year preceding enrollment. This FFQ was previously validated with 12 monthly 24 h recalls for food groups and nutrients, resulting in a median relative validity (Pearson's correlations) of 0.53 for women and 0.61 for men.[18,19] By including information on preparation methods and additions, consumption of 178 food items was estimated. Food groups (e.g. fruits and vegetables) were created and nutrient intake was estimated using an extended version of the 1996 computerized Dutch food composition table.[20] Food groups and nutrients were combined to construct the mMDS, as described by Trichopoulou *et al.*[21] In this score individual intake of food groups and nutrients is compared with the sex-specific median value of the study population. For vegetables, legumes, fruits, nuts and seeds, cereals, fish and the ratio of unsaturated to saturated fatty acids, intakes equal to or above the median were assigned a value of 1, and intakes below the median a value of 0. For meat and dairy products, intakes equal or below the median were assigned a value of 1. We included moderate alcohol intake in the score and assigned a value of 1 to consumption of 10–50 g (men) or 5–25 g (women) alcohol per day. The mMDS score ranges from 0 (minimal adherence) to 9 (maximal adherence). A higher score represents better adherence to the defined pattern. In this study a low adherence (score 0–3) was classified as having an unhealthy diet. The full distribution of the score in our study population is shown in Supplementary Table S1. We also computed results excluding alcohol from the score. The inclusion of alcohol in a healthy dietary pattern is still heavily debated. Moderate alcohol consumption has been associated with a reduced risk of cardiovascular disease,[22] but an increased risk of some cancers.[23] We therefore included a sensitivity analysis where we excluded 'alcohol intake' from the mMDS score. The mMDS score excluding alcohol ranges from 0 (minimal adherence) to 8 (maximal adherence), a low adherence (score 0–3) was classified as having an unhealthy diet.

Educational level

The general questionnaire provided data on educational level, based on the highest level of completed school education. For this study we defined low (primary school, n = 6441), mid-low (lower vocational training, n = 16316), mid-high (secondary school or intermediate vocational training, n = 8590) and high education (higher vocational training or university, n = 8046). In our analysis we focus on participants with the lowest vs. the highest educational level in order to create as much contrast as possible.

Lifestyle–related factors

The general questionnaire included information on smoking habits, physical activity level and dietary supplement use. Smoking status was categorized into never, former or current smoker. Physical activity level was based on hours spent in occupational activity, cycling and sports activity and categorized into inactive, moderately inactive, moderately active or active using the Cambridge Physical Activity Index.[24] Ever use of dietary supplements was included as a dichotomous variable. BMI and waist circumference were calculated from anthropometric measurements taken during the physical examination. BMI was categorized into normal weight (<25 kg/m^2), overweight (25–30 kg/m^2) and obese (>30 kg/m^2). Waist circumference was categorized based on guidelines of the World Health Organization[25] into normal (females <80 cm, males <94 cm), moderately increased (females 80–88 cm, males 94–102 cm) or large (females $\geq$ 88 cm, males $\geq$ 102 cm). The FFQ included information on breakfast frequency (daily or less).

Covariates

The general questionnaire included information and pre-existing diseases (heart disease, diabetes mellitus, cancer), these pre-existing diseases were combined into one dichotomous measure for prevalent disease (present or not). Working status was categorized into having a paid job and being without a paid job. The latter included retired participants.

Statistical analysis

Characteristics of the study population (n = 39 393) are presented as a percentage, a mean with standard deviation or as a median with interquartile range. They are presented for the total study population and separately for participants with a low (n = 6441) and participants with a high (n = 8046) educational level. The association between the lifestyle-related factors (independent variables) and low adherence to a Mediterranean-style diet (outcome) was investigated with logistic regression analysis. Odds ratios and 95% CI are presented. Relationships were adjusted for sex, age, working status, prevalent diseases, and mutually for all other factors. Participants with missing data on dietary supplement use (n = 251) were excluded in the corresponding analyses. Interaction between factors and educational level was tested by including interaction terms in the model. We included the lowest and highest educational level only (n = 14 = 388), as we are specifically interested in the extremes to allow for sufficient contrast to detect differences. Additionally, we studied above relations by strata of educational level. We report education-specific descriptive associations, our goal is not to elucidate causal relations between lifestyle-related factors and diet. A P values for trend was computed by including the lifestyle-related factor as a continuous variable in the model. We performed sensitivity analyses to investigate the effect of excluding participants with a low BMI (<18.5 kg/m^2) and the effect of excluding alcohol from the mMDS score. All statistical analyses were conducted using SAS 9.2 (SAS Institute, Cary, USA).

Results

Characteristics of the study population are presented in Table 1 for the total population and for the low and high educated group. The majority of our study population (74%) was female. Mean age of the study population was 49.2 years. Primary school (low educational level) was the only education for 16% of the study population, while 20% had a high educational level. A low mMDS was reported by 30% of the total study population; 39% in the low educated group and 20% in the high educated group. Participants with a low educational level were older, more often female and more likely to be overweight than participants with a high educational level. Moreover, the low educated group included fewer never smokers and was more often physically inactive.

Associations between lifestyle-related factors and an unhealthy diet are presented in Table 2 for the total population and for the low and high educated group. In the total study population, being obese or having a large waist circumference was associated with having an unhealthy diet [OR [95% CI] for having an unhealthy diet among obese compared with normal weight participants was 1.31 [1.22; 1.40], OR [95% CI] for having an unhealthy diet among large waist compared with normal waist participants was

Table 1 Characteristics of the total EPIC-NL study population, and for those with a low and high educational level

			Total population *N* = 39 393	Educational level Low (*n* = 6441)	High (*n* = 8046)
Age, in years		Mean (SD)	49.2 (11.9)	56.0 (9.1)	46.5 (11.0)
Sex	Females	N (%)	29 335 (74%)	5342 (83%)	5353 (67%)
Prevalent disease	Yes	N (%)	3740 (9%)	966 (15%)	548 (7%)
BMI, kg/m^2		Mean (SD)	25.7 (4.0)	27.3 (4.4)	24.4 (3.3)
BMI categories[a]	Normal weight	*n* (%)	18 131 (46%)	1830 (28%)	4919 (61%)
	Overweight	*n* (%)	15671 (40%)	2989 (46%)	2607 (32%)
	Obese	*n* (%)	5591 (14%)	1622 (25%)	520 (6%)
Smoking status	Never	*n* (%)	15 087 (38%)	2613 (41%)	3129 (39%)
	Former	*n* (%)	12 318 (31%)	1714 (27%)	2750 (34%)
	Current	*n* (%)	11 988 (30%)	2114 (33%)	2167 (27%)
Alcohol consumption, in grams ethanol per day		Median (IQR)	4.9 (15.0)	1.3 (8.2)	10.2 (18.2)
Physical activity level	Inactive	*n* (%)	3077 (8%)	878 (14%)	457 (6%)
	Moderately inactive	*n* (%)	9814 (25%)	1781 (28%)	1987 (25%)
	Moderately active	*n* (%)	10 206 (26%)	1410 (22%)	2405 (30%)
	Active	*n* (%)	16 296 (41%)	2372 (37%)	3197 (40%)
Dietary supplement use	Yes	*n* (%)	13 338 (34%)	1855 (29%)	3220 (40%)
Frequency of breakfast consumption	Daily	*n* (%)	32 388 (82%)	5469 (85%)	6485 (81%)
Unhealthy diet (mMDS < 4)		*n* (%)	11 770 (30%)	2507 (39%)	1620 (20%)
Working status	Working	*n* (%)	24 036 (61%)	4288 (67%)	6423 (80%)

a: Categorized into normal weight (<25 kg/m^2), overweight (25–30 kg/m^2) and obese (>30 kg/m^2).

Table 2 Odds ratios (95% CI) for having an unhealthy diet, in the total study population and stratified by educational level[a]

		Total population (*n* = 39 393)		Educational level				Interaction with educational level[b]
				Low (*n* = 6379)		High (*n* = 8009)		
		OR (95% CI)	*P* for trend	OR (95% CI)	*P* for trend	OR (95% CI)	*P* for trend	
BMI [3]	Normal weight	Reference	<0.0001	Reference	0.08	Reference	0.0002	<0.0001
	Overweight	1.09 (1.04; 1.15)		0.99 (0.88; 1.12)		1.09 (0.96; 1.24)		
	Obese	1.31 (1.22; 1.40)		1.14 (0.99; 1.31)		1.59 (1.29; 1.96)		
Waist circumference[c]	Normal	Reference	<0.0001	Reference	0.04	Reference	<0.0001	<0.0001
	Moderately increased	1.10 (1.04; 1.16)		1.06 (0.93; 1.22)		1.17 (1.02; 1.34)		
	Large	1.32 (1.25; 1.40)		1.14 (1.00; 1.30)		1.47 (1.25; 1.72)		
Smoking	Never	Reference	0.0034	Reference	<0.0001	Reference	0.0048	<0.0001
	Former	0.79 (0.75; 0.84)		0.98 (0.86; 1.12)		0.80 (0.70; 0.92)		
	Current	1.11 (1.05; 1.17)		1.42 (1.25; 1.61)		0.89 (0.78; 1.02)		
Physical activity	Active	Reference	<0.0001	Reference	0.0006	Reference	<0.0001	0.63
	Moderately active	1.04 (0.98; 1.10)		0.97 (0.84; 1.12)		1.12 (0.98; 1.29)		
	Moderately inactive	1.16 (1.10; 1.23)		1.21 (1.06; 1.39)		1.35 (1.17; 1.55)		
	Inactive	1.36 (1.25; 1.48)		1.26 (1.06; 1.49)		1.37 (1.08; 1.74)		
Dietary supplement use	Yes	Reference		Reference		Reference		0.14
	No	1.22 (1.16; 1.28)		1.08 (0.96; 1.21)		1.13 (1.01; 1.27)		
Frequency of breakfast	Daily	Reference		Reference		Reference		0.75
	Less than daily	1.27 (1.20; 1.35)		1.29 (1.11; 1.49)		1.28 (1.12; 1.46)		

a: adjusted for age, gender, working status, prevalent diseases, and the other factors. An unhealthy diet is defined as low mMDS (mMDS < 4);
b: interaction term is calculated for a model including the low and high educational level only (*n* = 14 388);
c: BMI and waist are not adjusted for each other.

1.32 [1.25; 1.40]). Significant interactions were found with educational level ($P < 0.0001$): associations were stronger in the high educated group, although borderline significant associations in the same direction also existed in the low educated group. An inactive lifestyle, no daily breakfast and no dietary supplement use were all associated with an unhealthy diet in the total population. These associations were present both in low and high educated persons. The association of smoking status with an unhealthy diet clearly differed by level of education (P interaction < 0.0001). Among low educated persons, current smokers reported an unhealthy diet more frequently than never smokers (OR 1.42 [95% CI: 1.25; 1.61]), while among highly educated participants, smokers less frequently reported an unhealthy diet (OR 0.89 [0.78; 1.02]). Highly educated former smokers also less frequently reported an unhealthy diet than highly educated never smokers (OR 0.80 [0.70; 0.92]). In contrast, former smoking was not associated with an unhealthy diet in the group with a low education. Excluding participants with a BMI below 18.5 kg/m^2 did not alter the results substantially, nor did excluding alcohol from the mMDS (Table 3).

Discussion

We investigated whether associations between lifestyle-related factors and an unhealthy diet, defined as a low adherence to a Mediterranean-style diet, differ by educational level. Most associations were consistent across low and high educational level and

Table 3 Sensitivity analysis: odds ratios (95% CI) for having an unhealthy diet, in the total study population and stratified by educational level[a]

		Total population (n = 39 393)		Stratified by educational level				Interaction with educational level[b]
				Low (n = 6379)		High (n = 8009)		
		OR (95% CI)	*P* for trend	OR (95% CI)	*P* for trend	OR (95% CI)	*P* for trend	
BMI [3]	Normal weight	Reference	<0.0001	Reference	0.18	Reference	0.0038	0.05
	Overweight	1.07 (1.02; 1.12)		0.96 (0.85; 1.08)		1.10 (0.98; 1.22)		
	Obese	1.19 (1.11; 1.27)		1.11 (0.96; 1.27)		1.33 (1.09; 1.62)		
Waist circumference[3]	Normal	Reference	<0.0001	Reference	0.19	Reference	0.0001	0.22
	Moderately increased	1.09 (1.04; 1.15)		1.03 (0.90; 1.18)		1.18 (1.05; 1.33)		
	Large	1.22 (1.16; 1.28)		1.09 (0.96; 1.23)		1.29 (1.12; 1.49)		
Smoking	Never	Reference	<0.0001	Reference	<0.0001	Reference	0.65	<0.001
	Former	0.93 (0.88; 0.97)		1.10 (0.97; 1.24)		0.94 (0.84; 1.06)		
	Current	1.24 (1.18; 1.30)		1.59 (1.40; 1.80)		1.04 (0.92; 1.17)		
Physical activity	Active	Reference	<0.0001	Reference	0.0095	Reference	<0.0001	0.16
	Moderately active	1.07 (1.01; 1.13)		0.94 (0.82; 1.08)		1.17 (1.04; 1.32)		
	Moderately inactive	1.19 (1.13; 1.26)		1.14 (1.00; 1.31)		1.36 (1.20; 1.54)		
	Inactive	1.34 (1.24; 1.45)		1.19 (1.01; 1.41)		1.38 (1.11; 1.71)		
Dietary supplement use	Yes	Reference		Reference		Reference		0.02
	No	1.22 (1.16; 1.27)		1.05 (0.93; 1.17)		1.18 (1.07; 1.31)		
Frequency of breakfast	Daily	Reference		Reference		Reference		0.57
	Less than daily	1.33 (1.26; 1.40)		1.30 (1.13; 1.51)		1.27 (1.12; 1.43)		

a: adjusted for age, gender, working status, prevalent diseases, and the other factors. An unhealthy diet is defined as low mMDS (mMDS excluding alcohol < 4);

b: interaction term is calculated for a model including the low and high educational level only (n = 14 388);

c: BMI and waist are not adjusted for each other.

comparable to those observed in the total study population. The association of smoking with an unhealthy diet clearly differed by educational level: opposite associations were found. Current smokers had a greater odds of an unhealthy diet compared with never smokers if they had a low educational level, but a lower odds of an unhealthy diet if they had a high educational level. Additionally, we found a lower odds of an unhealthy diet for former compared with never smokers among high educated, but not among low educated participants. Although also for BMI and waist circumference significant interactions with educational level were found, we did not observe clear different associations in low and high educated participants.

Other studies mostly report on a clustering of unhealthy behaviours in persons with a low socio-economic status.[10,26] In this study, we investigated if unhealthy behaviors and an unhealthy diet were related in a similar way in low and high educated people. For smoking, opposite associations were found in participants with a low vs. high educational level. We do not know the reason for this result, but speculate that high educated people who smoke may be more aware of their unhealthy smoking behaviour and compensate this (intentionally or unintentionally) by adapting other healthier behaviours, such as a healthy diet. It has to be noted that the current smokers may be a heterogeneous group of daily and non-daily smokers. Unfortunately we could not distinguish between these groups. We did compare the smoking intensity of low and high educated smokers: low educated smokers less often smoked <5 cigarettes a day (8 vs. 16%), which suggests that low educated smokers may be smoking on a daily basis more often. Furthermore, they were less often pipe smoker (2 vs. 10%). This may indicate that low educated smokers have worse smoking habits than high educated smokers. A similar effect as found in current smokers may exist in high educated former smokers. High educated former smokers reported less often an unhealthy diet compared with never smokers, suggesting they adapted an overall healthier lifestyle. We previously reported that a combination of four lifestyle factors was associated with a longer life in good health and should be taken together in health promotion strategies.[3] Smoking status was associated with the largest health gain. We now showed that current low educated smokers had a greater odds of an unhealthy diet, while high educated smokers do not. This suggests that educational level should be taken into account in the development of targeted health promotion strategies.

We defined a healthy dietary pattern by the mMDS. Mullie *et al.*[9] investigated the relationship between socioeconomic status and three dietary patterns, using the Healthy Eating Index, the Mediterranean Diet Score and a pattern based on principal component analysis. Higher adherence to all three patterns was associated with a higher socioeconomic status. Consistent with our results, a low educational level,[7,27] being physically inactive[7,27] and smoking[7] have all been related to a lower adherence to a Mediterranean-style diet before. In contrast to our results, skipping breakfast was not significantly associated with adherence to a Mediterranean diet in a study on obesity-related eating behaviours.[28] However, that study investigated the association with never having breakfast, while we investigated less than daily breakfast frequency. Skipping breakfast has been associated with a lower chance of meeting recommended nutrient intakes, unhealthier dietary patterns and associated chronic diseases.[14] Our finding that dietary supplement use is associated with having a healthier diet has also been observed in other studies.[12,13] Dietary supplement users may be more health conscious and have a healthier lifestyle overall.[29]

Strengths of our study are the use of a large population that included detailed information on diet, lifestyle-related factors and educational level. Several limitations need to be addressed as well. Dietary patterns were based on self-reported intake from a FFQ. Furthermore, detailed information on several lifestyle-related factors was available in our study, but we lacked information on social-cultural and economic factors. These factors may also be associated with a healthy diet[30].

In conclusion, associations between lifestyle-related factors and unhealthy diet were consistent across educational levels. Differences were only found for current and former smokers: in low educated persons, current smoking was related to an unhealthy diet in comparison to never smoking, whereas in high

educated persons current and former smoking was related to a healthier diet. These results can be used in the development of targeted health promotion strategies. If these strategies include smoking and diet, educational level of the target population should be taken into account.

Supplementary data

Supplementary data are available at *EURPUB* online.

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Conflicts of interest: None declared.

Keypoints

- Unhealthy dietary patterns have been associated with other unhealthy lifestyle factors, but if these associations are similar in high and low educated individuals is unknown.
- Most associations between lifestyle-related factors and unhealthy diet are consistent across educational levels, except for smoking.
- Health promotion strategies that include smoking and diet should take educational level of the target population into account.

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